

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11)

EP 1 321 779 A3

(12)

## EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
24.03.2004 Bulletin 2004/13

(51) Int Cl.7: G01V 11/00, G01V 3/15,  
G01C 21/00, G09B 29/10

(43) Date of publication A2:  
25.06.2003 Bulletin 2003/26

(21) Application number: 03075551.6

(22) Date of filing: 13.04.1995

(84) Designated Contracting States:  
DE FR GB

(71) Applicant: RADIODETECTION LIMITED  
Bristol BS14 0AZ (GB)

(30) Priority: 18.04.1994 US 228686

(72) Inventor: Haddy, Alan  
New Jersey, Oakland 07436 (US)

(62) Document number(s) of the earlier application(s) in  
accordance with Art. 76 EPC:  
95302493.2 / 0 683 401

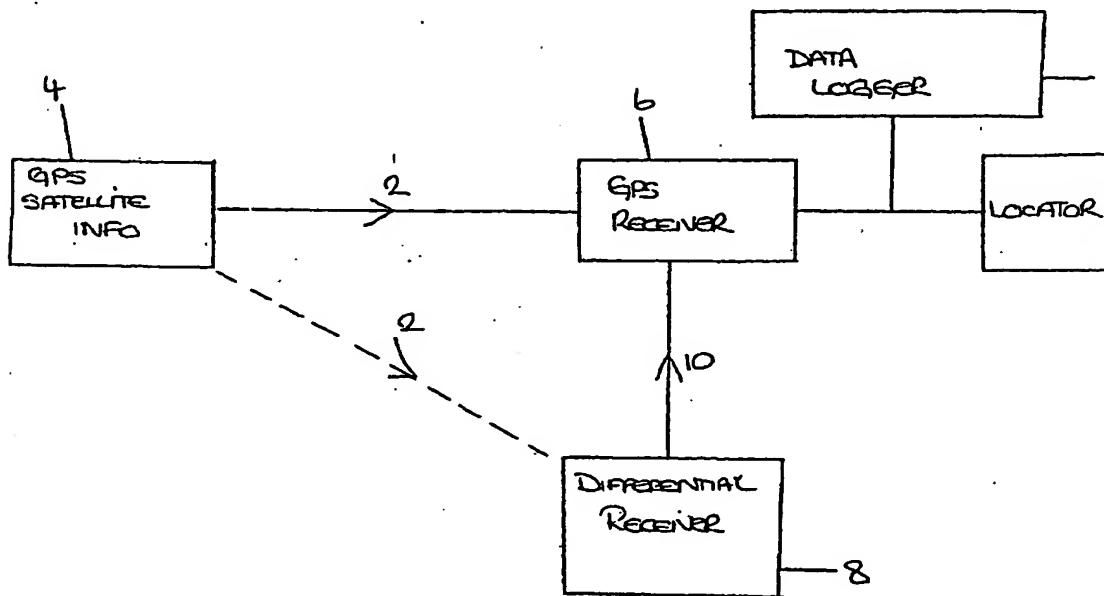
(74) Representative: Collins, John David  
Marks & Clerk,  
57-60 Lincoln's Inn Fields  
London WC2A 3LS (GB)

### (54) Locating device

(57) A locating device is disclosed which includes:  
positional data receiving means (6) for receiving data  
relating to the geographical position of the locating  
device; data storage means (12) for storing data relating  
to the position of the underground object (16); means  
for comparing the stored data with the positional data;

and means for producing a warning signal when said  
means for comparing indicates that the underground ob-  
ject is within a predetermined distance of the locating  
device.

In this way the geographical positional data is  
stored relating to the location of the underground cable,  
and is retrieved for relocation of the cable.





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

EP 03 07 5551

| DOCUMENTS CONSIDERED TO BE RELEVANT  |   |                   |  |                 |                                  |          |           |                 |              |
|--|---|-------------------|--|-----------------|----------------------------------|----------|-----------|-----------------|--------------|
| Category   | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6)   |                 |                                  |          |           |                 |              |
| X  | US 5 214 757 A (MAUNNEY THAD ET AL)<br>25 May 1993 (1993-05-25)<br>* column 5, line 59 - line 60; claims 1,2<br>*<br>* abstract; figures 1-3 *  | 2,3               | G01V11/00<br>G01V3/15<br>G01C21/00<br>G09B29/10                                      |                 |                                  |          |           |                 |              |
| Y  | US 5 067 081 A (PERSON CARL E)<br>19 November 1991 (1991-11-19)<br>* abstract *   | 1                 |  |                 |                                  |          |           |                 |              |
| A  | US 5 243 528 A (LEFEBVRE REBECCA K)<br>7 September 1993 (1993-09-07)<br>* column 3, line 25 - line 49 *<br>* column 4, line 62 - column 5, line 4 *   | 1                 |  |                 |                                  |          |           |                 |              |
| Y  | US 4 675 676 A (TAKANABE KAZUNORI ET AL)<br>23 June 1987 (1987-06-23)<br>* abstract *   | 1                 |  |                 |                                  |          |           |                 |              |
| Y  | UENO H ET AL: "Development of a mobile mapping system for use in emergency gas line maintenance vehicles"<br>VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE, 1989. CONFERENCE RECORD TORONTO, ONT., CANADA 11-13 SEPT. 1989, NEW YORK, NY, USA, IEEE, US, 11 September 1989 (1989-09-11), pages 177-184, XP010034446 ISBN: 0-9692316-2-8<br>* page 184, line 1 - line 30 *<br>* the whole document *<br>* page 179, right-hand column, line 1 - line 3 *<br>---<br>-/- | 1                 | TECHNICAL FIELDS SEARCHED (Int.Cl.6)<br>G01V<br>G01C<br>A01B<br>G06T<br>G09B<br>G01S |                 |                                  |          |           |                 |              |
| <p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 33%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>27 January 2004</td> <td>De Bekker, R</td> </tr> </table> <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/> Y : particularly relevant if combined with another document of the same category<br/> A : technological background<br/> O : non-written disclosure<br/> P : intermediate document</p> <p>T : theory or principle underlying the invention<br/> E : earlier patent document, but published on, or after the filing date<br/> D : document cited in the application<br/> L : document cited for other reasons<br/> &amp; : member of the same patent family, corresponding document</p> |   |                   |  | Place of search | Date of completion of the search | Examiner | THE HAGUE | 27 January 2004 | De Bekker, R |
| Place of search  | Date of completion of the search  | Examiner          |  |                 |                                  |          |           |                 |              |
| THE HAGUE  | 27 January 2004   | De Bekker, R      |  |                 |                                  |          |           |                 |              |



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 03 07 5551

| DOCUMENTS CONSIDERED TO BE RELEVANT   |   |                                  |  |
|---|---|----------------------------------|--|
| Category  | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim                | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
| A   | EP 0 576 121 A (CHEM EQUIPMENT CO LTD AG)<br>29 December 1993 (1993-12-29)<br>* abstract *<br>* page 7, column 11, line 51 - column 12, line 9 *<br>---                                 | 1                                |  |
| X   | US 4 727 329 A (BEHR RICHARD A)<br>23 February 1988 (1988-02-23)<br>* abstract *  | 2-5,8,9                          |  |
| Y   | * figures 1-5 *   | 6-8                              |  |
| A   | * column 1, line 51 - column 2, line 38 *<br>* column 3, line 8 - line 40 *<br>* column 5, line 15 - column 5, line 66;<br>claim 1 *<br>* column 6, line 2 - line 26 *                  | 1                                |  |
| Y   | WO 91 20002 A (CHARLES MACHINE WORKS)<br>26 December 1991 (1991-12-26)  | 6,7                              |  |
| A   | * abstract; claims 21-23,30; figure 5 *<br>* page 3, line 10 - page 6, line 5 *   | 8                                |  |
| A   | PATENT ABSTRACTS OF JAPAN<br>vol. 018, no. 223 (P-1729),<br>21 April 1994 (1994-04-21)<br>& JP 06 018649 A (KOKUSAI DENSHIN DENWA CO LTD), 28 January 1994 (1994-01-28)<br>* abstract * | 6                                | TECHNICAL FIELDS<br>SEARCHED (Int.Cl.6)      |
| P,A   | -& US 5 345 245 A (ISHIKAWA HIROYASU ET AL) 6 September 1994 (1994-09-06)<br>* abstract; figure 1 *<br>* column 4, line 1 - line 2 *  | 6                                |  |
| Y   | US 4 390 836 A (BRUCE CHARLES R ET AL)<br>28 June 1983 (1983-06-28)<br>* abstract; figures 1-4 *  | 8                                |  |
| The present search report has been drawn up for all claims  |   |                                  |  |
| Place of search   |   | Date of completion of the search | Examiner                                     |
| THE HAGUE   |   | 27 January 2004                  | De Bekker, R                                 |
| CATEGORY OF CITED DOCUMENTS   |   |                                  |  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document   |   |                                  |  |
| T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |   |                                  |  |



European Patent  
Office

Application Number  
EP 03 07 5551

### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
  
- No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
  
- As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
  
- Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
  
- None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



European Patent  
Office

LACK OF UNITY OF INVENTION  
SHEET B

Application Number  
EP 03 07 5551

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claim : 1

a locating device for underground objects as known by US4727329, which discloses positional data receiving means, data storage means and means for comparing the received data with the stored data, characterised by the means to produce a warning signal based on the result of the comparisson.

2. Claims: 2-9

a locating device for underground objects characterised by the means used in that special signal are detected which come from the object.

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 07 5551

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-01-2004

| Patent document cited in search report |   | Publication date |  | Patent family member(s)  | Publication date   |
|--|---|------------------|--|--|--|
| US 5214757                             | A | 25-05-1993       | AU<br>WO   | 8738991 A<br>9202891 A1  | 02-03-1992<br>20-02-1992   |
| US 5067081                             | A | 19-11-1991       | NONE   |  |  |
| US 5243528                             | A | 07-09-1993       | JP<br>WO   | 5502521 T<br>9204683 A1  | 28-04-1993<br>19-03-1992   |
| US 4675676                             | A | 23-06-1987       | JP<br>JP<br>JP<br>JP<br>JP<br>JP<br>JP<br>JP<br>JP<br>DE<br>EP | 1739154 C<br>4023794 B<br>59164583 A<br>1898722 C<br>6013973 B<br>59206710 A<br>1617761 C<br>2046086 B<br>59216016 A<br>3474607 D1<br>0118886 A2 | 26-02-1993<br>23-04-1992<br>17-09-1984<br>23-01-1995<br>23-02-1994<br>22-11-1984<br>12-09-1991<br>12-10-1990<br>06-12-1984<br>17-11-1988<br>19-09-1984 |
| EP 0576121                             | A | 29-12-1993       | US<br>AU<br>CA<br>DE<br>DE<br>EP<br>ES<br>NZ<br>US             | 5220876 A<br>3717493 A<br>2095462 A1<br>69301868 D1<br>69301868 T3<br>0576121 A1<br>2086881 T3<br>247475 A<br>RE35100 E                          | 22-06-1993<br>23-12-1993<br>23-12-1993<br>25-04-1996<br>11-11-1999<br>29-12-1993<br>01-07-1996<br>27-11-1995<br>28-11-1995                             |
| US 4727329                             | A | 23-02-1988       | NONE   |  |  |
| WO 9120002                             | A | 26-12-1991       | US<br>AU<br>EP<br>WO   | 5264795 A<br>8224791 A<br>0535153 A1<br>9120002 A1   | 23-11-1993<br>07-01-1992<br>07-04-1993<br>26-12-1991   |
| JP 06018649                            | A | 28-01-1994       | JP<br>US   | 2904241 B2<br>5345245 A  | 14-06-1999<br>06-09-1994   |
| US 4390836                             | A | 28-06-1983       | NONE   |  |  |

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 321 779 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
25.06.2003 Bulletin 2003/26

(51) Int Cl.7: G01V 3/15, G01V 1/00

(21) Application number: 03075551.6

(22) Date of filing: 13.04.1995

(84) Designated Contracting States:  
DE FR GB

(72) Inventor: Haddy, Alan  
New Jersey, Oakland 07436 (US)

(30) Priority: 18.04.1994 US 228686

(74) Representative: Collins, John David  
Marks & Clerk,  
57-60 Lincoln's Inn Fields  
London WC2A 3LS (GB)

(62) Document number(s) of the earlier application(s) in  
accordance with Art. 76 EPC:  
95302493.2 / 0 683 401

(71) Applicant: RADIODETECTION LIMITED  
Bristol BS14 0AZ (GB)

### Remarks:

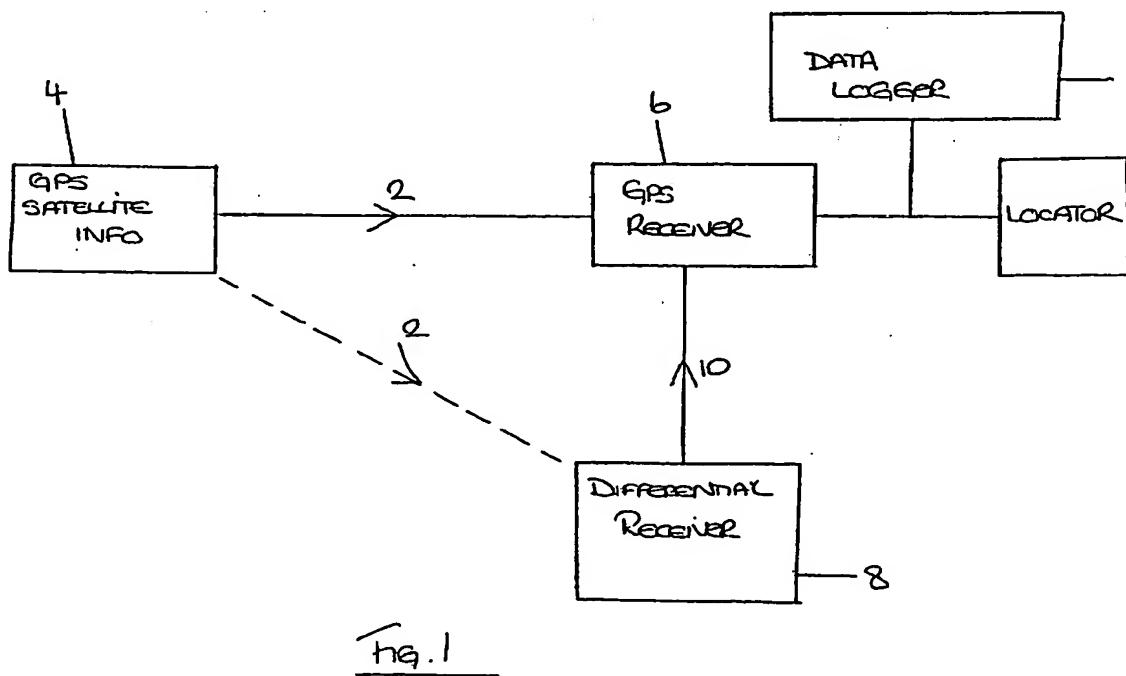
This application was filed on 25 - 02 - 2003 as a  
divisional application to the application mentioned  
under INID code 62.

### (54) Locating device

(57) A locating device is disclosed which includes:  
positional data receiving means (6) for receiving data  
relating to the geographical position of the locating de-  
vice; data storage means (12) for storing data relating  
to the position of the underground object (16); means  
for comparing the stored data with the positional data;

and means for producing a warning signal when said  
means for comparing indicates that the underground ob-  
ject is within a predetermined distance of the locating  
device.

In this way the geographical positional data is  
stored relating to the location of the underground cable,  
and is retrieved for relocation of the cable.



**Description**

[0001] The present invention relates to a locating device and in particular to a locating device for locating an underground object such as a cable or pipe.

[0002] Various types of locating devices e.g. for underground cables, are known. One such device, produced by the applicants, detects a magnetic field produced by an electric current in an underground cable using a pair of detector coils. The device gives an indication of when the user is directly above a portion of the buried underground cable. Typically, the user then marks the position of the cable on the ground surface and then moves along the cable detecting further portions of it. Thus the position of the length of cable can be determined.

[0003] Once the position of the cable has been determined it is useful to record this for future reference. Traditionally this would be done by simply recording, for example, that the cable lies a certain distance from the edge of a road, or alternatively by marking the cable on a map using conventional map surveying techniques.

[0004] Such recordal methods give rise to the problem that, when the user returns at a later date to re-locate the cable, they may need to re-use complex surveying techniques to relate the information on the map to the actual location. There is also the possibility that the physical feature (such as, in the above example, the road) which references the location of the cable has been moved. These problems render the repeatability of locating the cable more difficult, and furthermore involve the use of skilled techniques.

[0005] The present invention aims to reduce the complexity of recording the location of an underground object, such as a cable, and to increase the ease with which the object can be re-located.

[0006] Accordingly, the present invention provides a locating device including underground object locating means; positional data receiving means for receiving data relating to the geographical position of the locating device; and data storage means for storing data relating to the position of the locating device when an underground object is located, as determined by the geographical position of the locating device.

[0007] In this way the geographical positional data is stored relating to the location of the underground cable, and may be subsequently retrieved for re-location of the cable.

[0008] Instead of, or in addition to, storing data relating to the position of the locating device when an underground object is located, the data storage means may store data relating to the position of the underground object itself.

[0009] By using the present invention, the recordal of the geographical positional data of the underground cable may be permanent, and is not reliant on physical landmarks, e.g. roads etc., nor on the accuracy of a particular mapping system used. Furthermore, there is no

need to physically mark the location of the underground cable on the ground surface in order to survey it for mapping, which is necessary even where digital mapping systems are employed.

5 [0010] There exists geographical data sources known as geo-positional satellites (GPS) from which, typically, navigational information is obtained e.g. by sailors or mountaineers. A system utilising such satellite data is sometimes referred to as a Global Positioning System, and the same abbreviation GPS used.

[0011] Presently, 24 satellites are in orbit 11,000 miles above the earth (21 satellites are operational, 3 are back-ups). Each satellite contains four atomic clocks and broadcasts time data and other information identifying itself and describing its path. A GPS receiver compares the signals with its own clock(s) and then determines its location in terms of latitude and longitude by calculating the distance between it and the satellites. Typically, data may be obtained from 3 or 4 of the satellites and trigonometrical calculations performed to determine the position of the receiver.

[0012] The typical accuracy obtainable using a commercially available receiver is between 20 - 100 metres for this simple system. The accuracy of the system can be improved by adding data from a second, stationary, receiver and readings can then be refined to within a few centimetres.

[0013] Preferably the positional data receiving means include means for receiving GPS data. The positional data receiving means need not be physically located within the body of the locating device - the GPS receiver, for example, could be connected to a datalogger which in turn is connected e.g. via an interface (such as an RS232 interface) to the locating device. Alternatively, the locating device could be adapted to accept a PC memory card type GPS receiver.

[0014] In a preferred embodiment the positional data receiving means receives data from both overhead GPS satellite(s) and a second stationary (differential) receiver, thus improving the accuracy of the geographical location measurement. The data from the differential receiver may be received, for example, by radio transmission such as an FM link, or may be transmitted to the locating device via a fibre optic cable sheath. If an FM link is being used, the differential information may be received by the operator via a "beeper" type device, with the beeper being hard wired to the GPS receiver. The "beeper" type device may be a radio receiver which then passes the differential information to the GPS receiver.

[0015] The differential information may be provided by a plurality of land-based receivers - for example in the USA a network of around 300 FM stations provides the differential signal. A land station may be up to, for example, 200 miles away and still transmit receivable differential data.

[0016] Preferably, the locating device is of the type which detects a magnetic field produced by a current passing through an underground cable. The under-

ground object locating means may therefore include magnetic field detection means, such as a pair of detecting coils.

[0017] For the type of locating device described earlier, where the device detects the magnetic field produced by a current passing through an underground cable, the differential data may be modulated on to the signal which is passed through the cable. The locating device may then receive the data from the signal in the cable, for example using the two detection coils, thus removing the need for FM reception of the differential data. Since the rate of update of the GPS information is relatively slow, the typical modulation of the data on the cable may be low e.g. 10-20Hz.

[0018] Where the underground cable being located is suitable for carrying long distance data information, e.g. a telephone cable, the differential data may be transmitted along the line. Where the cable includes repeater stations, the differential data may be input on to the cable at a repeater station.

[0019] Preferably other features of the cable system are recordable. For example the position of cable joints may be recorded using this system together with a datalogger.

[0020] The positional data and/or any other data may be recorded in a buried RF identity marker. Such a marker, designed to be interrogated by a suitable transmitter/receiver, would be programmed with the longitude/latitude information, and then be buried above or near the target line cable; this data could also be recorded on a map of the target area (such maps being commonly called 'asbuilts' by A.T.& T and others). The map could then be used to point the operator to the area in which the market tag should be found next time location is required.

[0021] Once the data relating to the position of the cable has been logged it may then be stored and manipulated in any required fashion.

[0022] In a second aspect the present invention relates to a locating device including positional data receiving means for receiving data relating to the geographical position of the locating device; data storage means containing data relating to the location of an underground object; means for comparing the data stored in the data storage means with the data received by the positional data receiving means; and means for producing a warning signal when said means for comparing indicate that the underground object is within a predetermined distance of the locating device.

[0023] In other words, preferably the data relating to the location of the underground cable may be stored in a "beeper" type device, which device is also capable of receiving GPS data and comparing the received GPS data with the stored cable location data and producing an appropriate output when the two sufficiently coincide.

[0024] Such a device could, for example, be carried by workmen in order to prevent inadvertent interference

with a given underground cable.

[0025] The present invention also relates to a method of recording the position of a underground object, including the steps of:

- 5 (a) locating the object with a locating device;
- (b) receiving positional data relating to the geographical position of the locating device; and
- (c) storing data relating to the position of the underground object as determined by the geographical position of the locating device.

[0026] An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Fig 1 is a block diagram of a system according to one aspect of the present invention, and

- 20 Fig 2 is a schematic diagram showing the use of an embodiment of the present invention.

[0027] In Fig 1 GPS information 2 is produced by one or more GPS satellites 4. The positional information 2

- 25 is transmitted to a GPS receiver 6 and a differential receiver 8. The differential receiver 8 in turn transmits differential information 10 to the GPS receiver 6. The differential information 10 may be transmitted, for example, via an FM link, along a fibre optic cable sheath or
- 30 by modulating an electrical signal along the cable to be located/logged.

[0028] The GPS receiver 6 transmits information to a

- 35 data-logger 12. The data logger 12 also receives information from a locating device 14 which is used to locate, for example, an underground cable. The GPS receiver 6 and/or the data-logger 12 may be incorporated in the locator 14 or alternatively either or both of them may be external to the locator 14.

[0029] Thus the data logger 12 records information relating to the detection (or otherwise) of the underground cable and to the geographical location of the locating device. The location of the underground cable may then be recorded.

- 40 [0030] Fig 2 shows a schematic diagram of a locating device (not to scale) 14 being used to locate an underground cable 16. The underground cable 16, for example a telephone cable, includes repeater stations 18,20 to amplify the data signal as it passes along the cable 16. The cable is located by introducing a signal, for example at a repeater station, on to the cable and detecting the magnetic field 22 produced by the signal on the cable. The signal introduced on to the cable for this purpose may be, e.g. between 5Hz and 100KHz and is typically around 500Hz. Two detecting coils 24, 26 in the locating device 14 are used to detect the magnetic field 22.
- 45
- 50
- 55

[0031] Additionally, the locator 14 includes a GPS receiver 6 for reception of GPS positional data. Differential

data 10 is input on to the cable using a differential receiver 8 at the repeater station 18. The differential data 10 may be modulated on to the cable signal, for example at a modulation frequency of 10-20Hz. This differential data is received by the locator 14 using the reception means such as the detection coils 24, 26.

[0032] Various modifications to the invention may be envisaged. For example the differential data could be received by the GPS receiver by means other than an FM link or signal modulation. Additionally, the GPS receiver could be located remote from the locator and/or data logger and the positional data transmitted to the data logger via other conventional transmission methods.

### Claims

1. A locating device including:

positional data receiving means for receiving data relating to the geographical position of the locating device;  
data storage means containing data relating to the location of an underground object;  
means for comparing the data stored in the data storage means with the data received by the positional data receiving means; and  
means for producing a warning signal when said means for comparing indicate that the underground object is within a predetermined distance of the locating device.

2. A locating device (14) including:

underground object locating means (24, 26) for locating an underground object; characterised in that the device includes:

positional data receiving means (16) for receiving data relating to the geographical position of the locating device; and  
data storage means (12) for storing data relating to the position of the locating device when an underground object is located.

3. A locating device according to claim 2 wherein the positional data receiving means include means for receiving data from a Global Positioning System (GPS).

4. A locating device according to claim 3 wherein the positional data receiving means includes means for receiving data from both at least one GPS satellite and a second stationary receiver.

5. A locating device according to claim 4 wherein the

data from the stationary receiver is receivable by radio transmission.

6. A locating device according to claim 4 including means for receiving data from the stationary receiver which has been modulated on to a signal which is transmitted along a cable detected by the locating device.

10 7. A locating device according to claim 6 wherein the means for receiving the data from the stationary receiver includes two detection coils for detecting the magnetic field produced by a current passing through the underground cable.

15 8. An underground cable locating device according to any one of claims 2 to 7, wherein the underground cable locating means (24, 26) includes two detection coils for detecting a magnetic field produced by a current passing through the cable.

20 9. A method of recording the position of an underground object, including the steps of:

25 (a) locating the object with a locating device (14); characterised in that the method includes the steps of:  
(b) receiving positional data relating to the geographical position of the locating device; and  
(c) storing data relating to the position of the underground object as determined by the geographical position of the locating device.

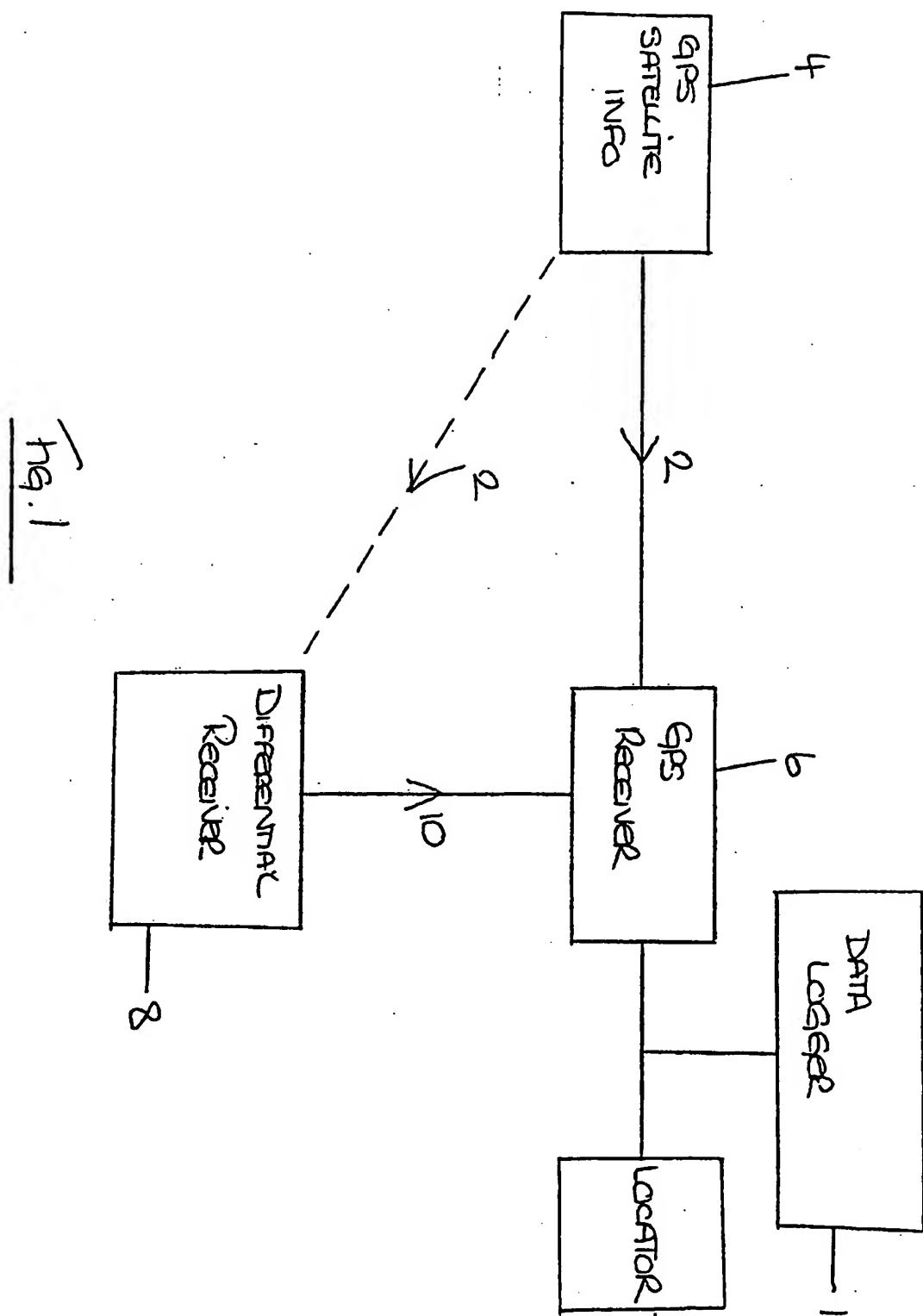
35

40

45

50

55



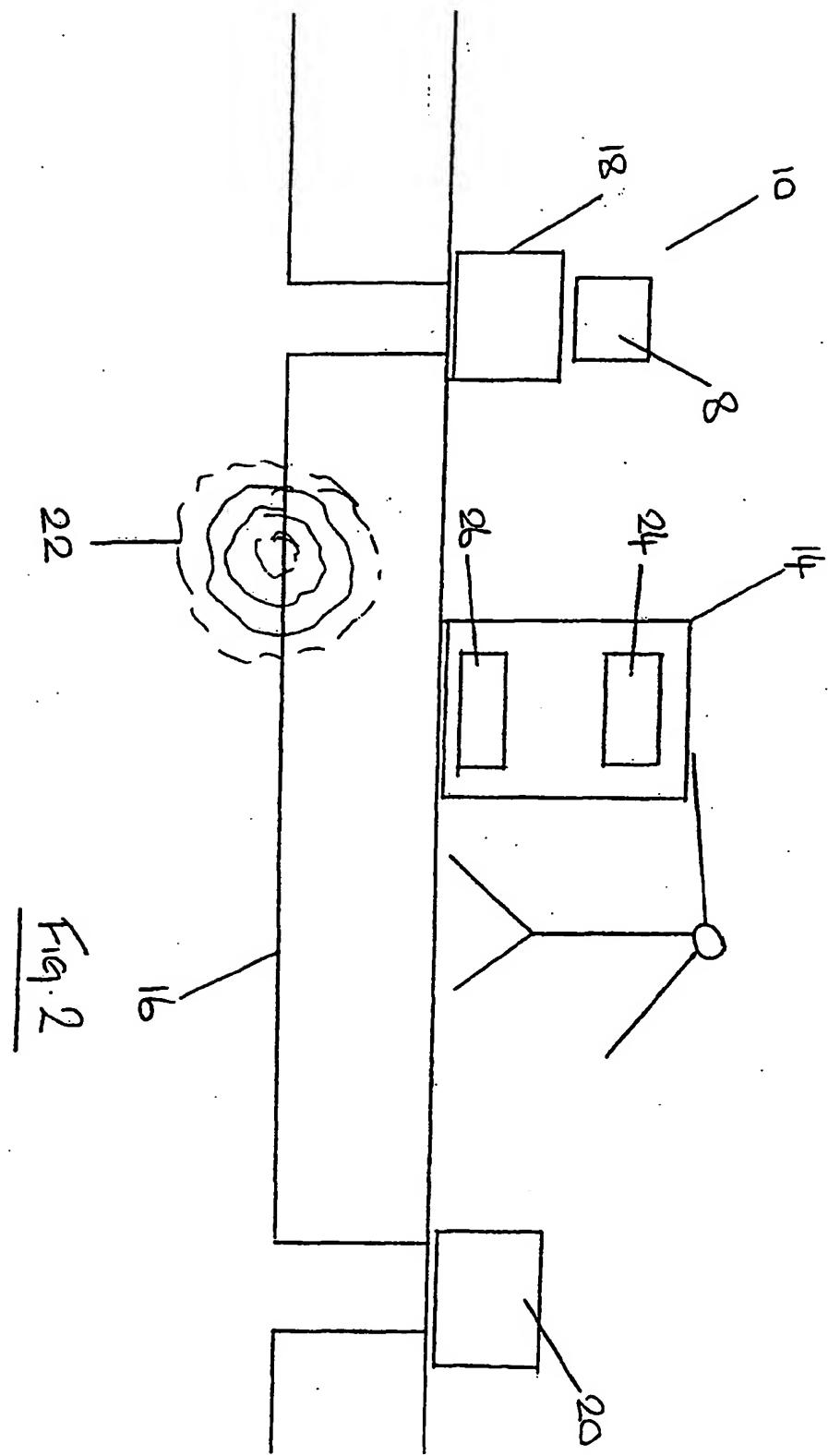


Fig. 2